Inventory and Report:
Seattle's Greenhouse Gas Emissions

City of Seattle

Office of Sustainability and Environment

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Contacts:
Kim Drury (206) 684-3214
Office of Sustainability and Environment: (206) 615-0817

City of Seattle Greenhouse Gas Inventory

INTRODUCTION

Global warming is occurring as a result of dramatically increased concentrations of atmospheric greenhouse gases, primarily carbon dioxide. While natural processes such as plant respiration and organic decomposition also release these gases, fossil fuel burning and other human activities have accelerated the accumulation of the gases to a level that exceeds the earth's capacity to absorb them as part of the natural cycle. The heat trapped by the greenhouse gases is raising average global temperatures to unprecedented levels – 1998 and 2001 are the warmest years on record.

Scientists project that, due to rising temperatures, the Pacific Northwest can expect higher temperatures, wetter winters, drier summers, reduced river flows, increased coastal flooding and erosion and decreased forest health and productivity. Snowpack – the region's natural storage system for water supply and hydroelectricity - is likely to decline by half by 2050. Responding to global climate change has been a City priority since the early 1990's.

In July 2001, via Resolution 30316, the Seattle Mayor and Council directed the City's Office of Sustainability and Environment (OSE) to:

- conduct an inventory of the City's greenhouse gas emissions (GHG) for 1990 and 2000;
- identify any existing programs that would have reduced Seattle's GHG emissions since 1990;
- project Seattle's GHG emissions in 2010;
- following completion of the inventory, prepare plans that would reduce Seattle's GHG emissions from seven to forty percent below 1990 levels.

OSE relied on the technical assistance of an Advisory Group[1] to help define the scope and boundaries of the inventory project and to resolve technical issues. With the input of the Advisory Group, several parameters for the project were agreed to:

- The primary purpose of the GHG inventory is to provide baseline data to inform City decision making, i.e., evaluate existing emission reduction programs and plan for further reductions.
- To the degree possible, the inventory will be compatible with standards that may be applied nationally or internationally in the future. Thus, for example, the Intergovernmental Panel on Climate Change (IPCC) 1996 national inventory guidelines were used for calculating quantities of emissions for each fuel type (e.g., coal, diesel, etc.). The World Resources Institute "GHG Protocol" provided a model for including emissions from purchased energy and indirect emissions sources.
- To be credible, the inventory and data base would be[2]:
  - Transparent, clearly documenting and explaining decisions on assumptions, sources of data, etc.
  - Complete, accounting for all relevant and material GHG emissions and activities within the boundaries selected for the inventory[3];
  - Accurate in accounting to provide assurance on the integrity of the data;
  - Consistent, allowing meaningful comparisons of emissions data over time.

[1] The Advisory Group was lead by OSE and included representatives from Seattle City Light, Seattle Public Utilities, the Mayor's Office, City Council Central Staff, King County Department of Natural Resources, the Puget Sound Clean Air Agency as well as a citizen volunteer with climate change expertise.

[2] Although not published until October 2001, these are essentially the same reporting principles contained in the "Greenhouse Gas Protocols", World Resources Institute and World Business Council for Sustainable Development.

[3] Material emissions are those of sufficient size to warrant analysis.

The inventory is intended to focus on emissions that are related both to the City's internal activities as a municipal government and to the emissions in the larger community that may be influenced by City policies and programs. To capture both of these sets of data, this document includes both a *City and Utility Operations GHG Inventory* and a *City Wide GHG Inventory.* Neither of these inventories provides a precise picture of the GHG emissions that the City can directly or indirectly influence. But together, they provide a good data base from which to identify emission reduction opportunities and an encouraging account of the emission reductions already achieved and planned.

Defining the Inventories

The *City and Utilities Operations* inventory is a comprehensive inventory of the major GHG emissions associated with or directly influenced by City operations and utility operations – ranging from fuel use by motor pool vehicles in downtown Seattle to City Light purchases of energy that originate from fossil fueled power plants to gasoline used by Parks Department lawnmowers. To the extent possible, this inventory also captures those significant GHG emissions that indirectly result from City operations – for example, emissions associated with the manufacture of cement which is used in pavement, and the methane emissions associated with the production and distribution of natural gas used to heat City buildings. While emissions due to City and utility operations represent a relatively small percentage of total GHG emissions in the Seattle area, they are the emission sources over which the Mayor and Council often have more direct influence or control.

The *City Wide* inventory is different from the *City Operations* inventory in that it uses the geographic City limits to define the "boundary" of what is included (with one major exception, SeaTac Airport; see note 4b.) Most of the data in the *City Wide* inventory has been provided by the Puget Sound Clean Air Agency[3] and includes all the major greenhouse gas emissions that actually occur within the City limits including the region's major source of greenhouse gas emissions – traffic – as well as emissions associated with industry, heating all the homes and businesses in the City, etc. Because only emissions within the city limits are counted (with the noted exception) unlike the *City Operations* inventory it does not include indirect emissions (also called upstream emissions.) It does include a sub-set of the *City and Utilities Operations* inventory (those that occur within City limits.)

Which greenhouse gas emissions are inventoried?

The major human-caused greenhouse gases that contribute to global warming are carbon dioxide, methane, nitrous oxide, hydrofluorcarbons, perfluorocarbons and sulfur hexafluoride. All are included except for nitrous oxide and perfluorocarbons, because emissions of these gases are insignificant in Seattle[4]. The global warming potential (GWP) is presented in parentheses.

- *Carbon dioxide (CO2),* is released to the atmosphere when fossil fuels (oil, natural gas, and coal), and wood and wood products are burned. It is the most prevalent of all greenhouse gases, accounting for 82% of total emissions in the US. (GWP = 1)
- *Methane* is emitted during the production and transport of coal, natural gas, and oil; the process of decomposition of organic wastes in municipal solid waste landfills, and the raising of livestock. It accounts for 10% of GHG emissions in the US. (GWP =23)

[3] In 2001, the Puget Sound Clean Air Agency decided to develop a climate protection program. As part of that initiative, they are inventorying GHG emissions within the corporate limits of King County and the City of Seattle.
[4] It isn't a factor because the type of industrial and agricultural processes that emit significant amounts of the gases, e.g., manufacturing nylon and fertilizing fields, do not occur in Seattle.

- *Hydrofluorocarbons* (HFCs) (GWP=140 to 6,300), *perfluorocarbons* (PFCs) (GWP = 6,500 to 9,200 and *sulfur hexafluoride* (SF6) (GWP = 23,900) are man-made gases used or generated by a variety of industrial activities.
- *Nitrous oxide* is emitted during agricultural and industrial activities, as well as during combustion of solid waste and fossil fuels. (GWP =296)

HFCs, PFCs and SF6 are by far the most potent of the greenhouse gases in their ability to trap atmospheric heat. To account for these different potencies, the GHG emissions for these gases have been converted to be equivalent to the weight of CO2, termed 'carbon dioxide equivalent.'

Where does carbon sequestration fit in?

The city-owned Cedar River Watershed contains roughly 85,000 forested acres. The living trees *remove* carbon dioxide from the atmosphere and store it as biomass. Commercial harvesting of timber did occur on a small scale in the watershed until 1995, and this resulted in *release* of carbon dioxide into the atmosphere from decay or burning of biomass. Recent research on sequestration and release of carbon in Pacific Northwest forests provided useful models for the estimates of these effects at the watershed which are included in the report.

FINDINGS

City and Utilities Operations

- The City has substantially reduced GHG emissions attributable to its operations and projections are that the trend will continue. The Kyoto Protocol calls for US emissions to be cut by seven percent below 1990 levels by 2012. Comparing 2000 to 1990, the City has already cut its emissions by 59 percent, primarily because it divested its interest in the Centralia Coal Plant. Other reductions are due to flaring methane at a closed City landfill and recycling programs that have reduced the emissions associated with the handling of solid waste.
- Projections are that by 2010, the City will cut its emissions by over 100 percent compared to 1990. In addition to the landfill reductions the other major reductions are due to City Light's commitment of no net GHG emissions by 2003, and the cessation of commercial harvesting at the Cedar River Watershed.
- Without the City's recycling and energy conservation programs, the City's emissions in 2000 would have been more than twice as large as they were.

Citywide

- Citywide emissions in 2000 remained essentially constant compared to 1990 but by 2010 are projected to increase by nearly 20 percent over 1990 levels.
- In 2000, transportation accounted for 56 percent of Seattle's GHG emissions compared to 31 percent for the nation as a whole. Transportation accounts for a higher percentage of our GHG emissions than the rest of the country because our region uses less coal or other GHG- emitting electric power sources.
- To fulfill the Kyoto Protocol goal of reducing emissions to seven percent below 1990 levels means that Seattle's emissions target would be 6.5 million metric tonnes[5] of CO2 equivalents (about 480,000 tonnes less than current levels.) To reach a forty percent reduction target would mean that Seattle's emissions would be 4.2 million tonnes of CO2 equivalents in 2010.
- Additional emissions were avoided through such measures as the changes to the City's energy code that require gas heated buildings to be more energy efficient and the regions'

[5] Metric tonnes is the internationally accepted unit of measurement for greenhouse gases. A US short ton = .90718 metric tonnes.

various transportation programs – transit, heavy rail, bicycle commuting and van and car pools – that increase mobility and reduce the use of single occupancy vehicles. However, data by which to estimate emissions reductions due to these measures are not available.

Overarching

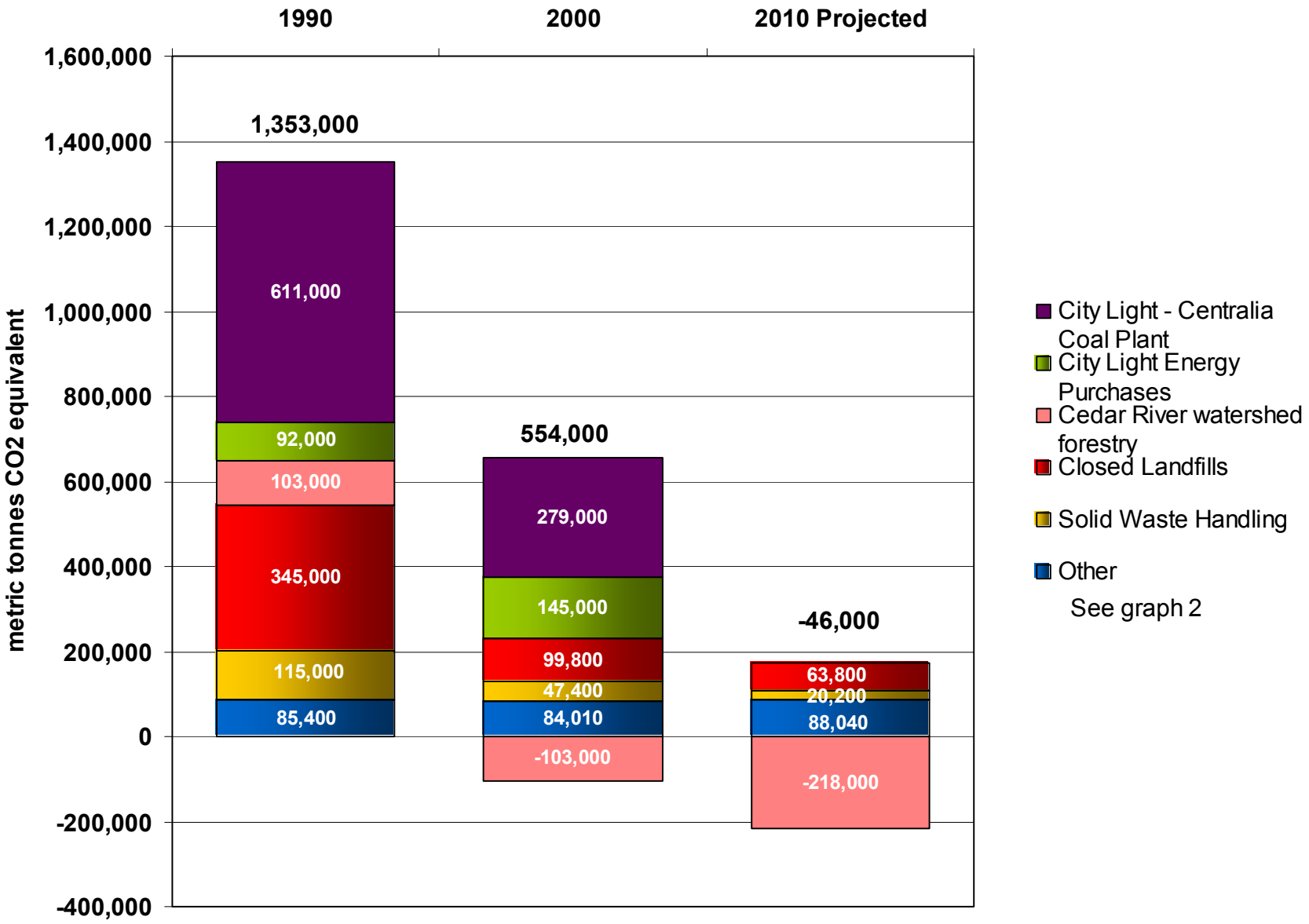
- The City's achievement in reducing emissions is significant, demonstrating that substantial GHG reductions are both attainable and consistent with other financial and environmental objectives. The City's strong performance also provides an important foundation for broader emission reduction activities in the community. Continued reductions in two major sources of emissions – electricity production and solid waste management – are directly connected to City policies and programs but the single largest source of emissions – transportation – is less direct. Achieving Resolution 30316's goal of reducing emissions by seven to forty percent will require a combined emphasis of reductions in both community wide emissions and City and Utility Operations' emissions.

Table A: City of Seattle Greenhouse Gas Emissions Inventory - City and Utilities' Operations

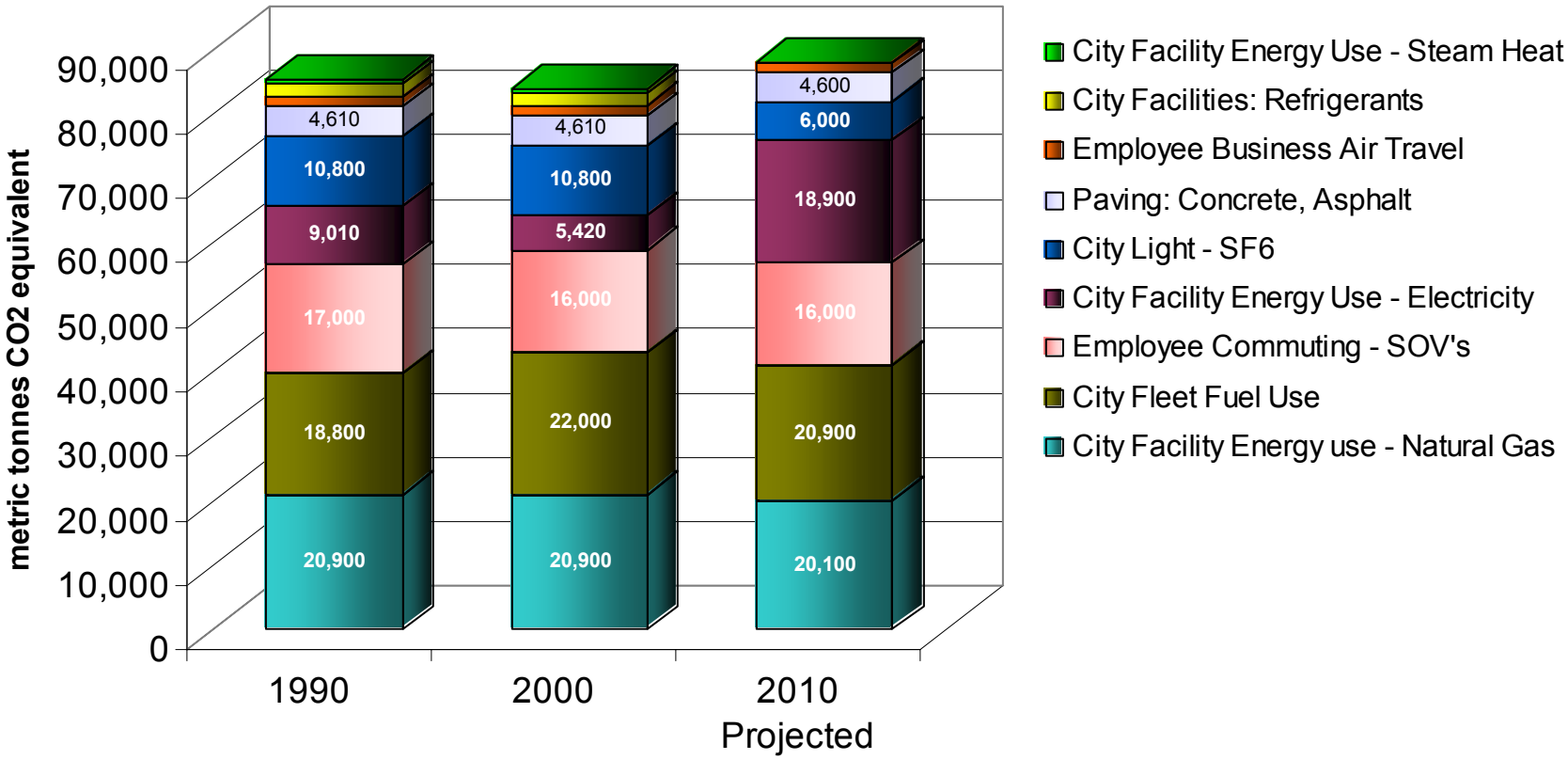
(all emissions are displayed in metric tonnes and have been converted to CO2 equivalents)

SOURCE		**1990**	**2000**	*Projected for 2010*
Note #				
1a.	***City Light – Centralia Coal Plant***[6]	611,000 (45.3%)	279,000	0
2a.	***City Light energy purchases***	92,000 (6.8%)	145,000	0
3a.	***Closed landfills***	345,000 (25.6%)	99,800	63,800
4a.	***Solid waste handling***	115,000 (8.5%)	47,400	20,200
5a.	***City facility energy use – natural gas***	20,900 (1.5%)	20,900	20,100
6a.	***Fleet fuel use***	18,800 (1.4%)	22,000	20,900
7a.	***Employee commuting – SOVs***	17,000 (1.3%)	16,000	16,000
8a.	***City Light – SF6***	10,800 (0.8%)	10,800	6,000
9a.	***Paving: concrete and asphalt***	4,610 (.3%)	4,610	4,600
10a.	***City facilities: refrigerants***	2,000 (.1%)	2,000	Unknown
11a.	***Employee business air travel***	1,540 (.1%)	1,540	1,400
12a.	***City facility energy use – electricity***	9,010 (.6%)	5,420	18,900
13a.	***City facility energy use – steam heat***	740 (.1%)	740	140
14a.	***Cedar River watershed forestry***	103,000 (7.6%)	Minus 103,000	Minus 218,000
	Total	**1,353,000 tonnes**	**554,000 tonnes**	**Minus 46,000 tonnes**
15a.	***Emissions avoided - SPU recycling***	407,000	539,000	891,000
16a.	***Emissions avoided - SCL conservation***	88,200	278,000	Unknown
17a.	***Emissions avoided - Muni Conservation (natural gas)***		398	Unknown
Total emissions if programs that reduce emissions had not occurred		**1,850,000 tonnes**	**1,370,000 tonnes**	**845,000 tonnes**

[6] The City sold its ownership share in Centralia Coal Plant in April 2000 for environmental and economic reasons.



Graph 1: ***Major Sources of GHG Emissions from City Government and Utility Operations***



Graph 2: ***Smaller Sources of GHG Emissions from City Government and Utility Operations***

GHG Inventory: City and Utilities' Operations.
Explanations, notes, etc. for Table A.

Original source data is on file at the Office of Sustainability and Environment. Below is a summary of where the data was obtained, how it was compiled, etc.

1a. **City Light - Centralia Coal Plant** Until May of 2000, City Light owned a share in the Centralia coal plant. The combustion of coal emits large quantities of carbon dioxide, as well as other pollutants. Electricity generation in older coal plants emits approximately 60 percent more CO2 than generation from modern gas fired plants. In April 2000, the City sold its share of the Centralia Coal Plant which substantially reduced its total GHG emissions.

2a. **City Light energy purchases** Included here are emissions from:

- Net short-term market purchases (using EPA Region 10's carbon intensity factor as a proxy for how much of the purchased energy originated from fossil fuels.) Because hydro resources vary year to year, the amount of energy that must be purchased on the market also varies; thus, emissions for 2000 were computed as an average of 1998-2000 purchases. Net short-term market purchases were less than 0 in all years except 1998 making it a very small source.
- Net purchases from BPA (long-term contracts) again using EPA Region 10's carbon intensity factor.

Projected SCL emissions for 2010 are zero (excluding SF6) based upon the City's adopted commitment for City Light to meet all of Seattle's electricity needs with zero net release of greenhouse gas emissions. Note: Sulfur hexaflourlide (SF6), used in electrical substations is listed separately (see note 8a.)

3a. **Closed landfills** A number of City owned landfills that are now closed continue to produce methane. Methane has a global warming potential 21 times that of carbon dioxide on a weight-for-weight basis. The significant decline in emissions from 1990 to 2000 is because a methane collection and flaring system was installed at Kent Highlands (Note: only un-flared methane is counted. Consistent with international protocols for GHG inventories, the CO2 produced by flaring at some of the landfills is not counted; carbon is largely from biomass such as crops or forests and is therefore part of the natural carbon cycle.) Projections for 2010 decline as the landfills continue to age and the decomposition process nears completion; projections are based on engineering models and time series data from these landfills. Data for this category were supplied by Seattle Public Utilities.

4a. **Solid waste handling** – Seattle's solid waste is managed by Seattle Public Utilities. The emissions in this category have been calculated by modeling (using the EPA WARM_02 model) the lifecycle of solid waste handled by SPU in 1990 and 2000 that has been transported and landfilled at Cedar Hills (1990) and Arlington, Oregon (2000.) Emissions are due to fossil fuels used by trains and trucks transporting the waste, and to methane produced by decomposition. The projected amount of emissions in 2010 from these sources also comes from the Warm_02 model from EPA, and is considerably smaller than the 2000 figure due to a 60% recycling target by 2010. This number is then increased by 1% per year to allow for Seattle population growth between 2000 and 2010. An 85% methane capture rate at the landfill is assumed.

5a. **City facility energy use – natural gas** The City owns and operates hundreds of buildings, many of which use natural gas for heating and hot water. Emissions were calculated by reviewing gas billing records provided by the various City departments; in some cases the

records stated the cost of the gas, and in some cases the records stated the actual number of therms. Using industry accepted assumptions, upstream leakage of natural gas during production and transmission was included in the emissions calculations. Because data was not available for 1990, the data for 2000 was used as a proxy. The 2000 figure was the starting point used to estimate the emissions from this source in 2010, Estimates of natural gas reductions due to planned capital projects at Parks and ESD reduced this number by 800 Metric tonnes.

6a. **Fleet fuel use** This includes all emissions associated with burning diesel, gasoline, compressed natural gas (CNG), propane and biodiesel to operate the City's extensive fleet of construction equipment, trucks, vans, cars, and other vehicles (e.g., meter reading scooters) as well as mowing machines, leaf blowers, etc. The data were provided by Fleets and Facilities Department which maintains records of fuel use by each department, and by remote City Light operations. Since data were not available for 1990, 1995 data was used for that year. Current proposals are to reduce fleet fuel use by 1% per year over five years (2001 to 2005), Therefore, projections for 2010 are assumed to equal : **[Year 2000 vehicle fleet emissions] times $(0.99)^5$. The result is [22,000 Metric Tonnes CO2 / year] * 0.951, or 20,900 Metric Tonnes CO2.** Note: Data were not available on fuel used by employees driving their personal vehicles for City business so emissions in this category are understated.

7a. **Employee commuting - SOVs** Employees who drive by themselves to and from work add emissions; some of these trips are by personal choice but in many cases an employee doesn't have a choice because of his or her job location, e.g., it isn't on a convenient bus route. The estimated emissions for this category are based on 2000 survey data collected by the City's Commute Trip Reduction Program (CTRP) and extrapolated to include employees not part of the survey, i.e., job sites not in the downtown core, swing and night shift employees, etc. The 2000 value was also used for the 2010 projection.

8a. **City Light – SF6** Sulfur hexafluoride (SF6) is used in City Light's electrical switchgear as a coolant and fire suppressant; it is one of the most potent global warming gases there is - *one pound of SF6 has the same global warming* potential *as approximately 10,800 lbs of CO2.* The figures for annual leakage of SF6 from City Light equipment in 2000 are approximate (1,000 pounds). A working group at SCL is improving these estimates and reducing the annual leakage. There are new technologies that reduce the amount of SF6 required in switchgear. For these reasons, the projected leakage of SF6 in 2010 has been reduced compared to the amount estimated for 2000.

9a. **Paving: concrete and asphalt** There are significant CO2 emissions associated with the manufacture of cement for concrete. The same is true of the production of bitumen for asphalt. In 2000, the City paved 3.8 lane miles of concrete, 25.7 lane miles of asphalt and used 66,000 tons of asphalt to fill potholes. Data on the volume of both concrete and asphalt used for paving during 2000 were provided by Seattle Transportation. The numbers used in these calculations came from current research on the lifecycle emissions for these products. The total emissions figure for 2000 was used for both 1990 and 2010 due to the lack of data for those years. There is a good possibility that CO2 emissions from concrete paving will be smaller in 2010, due to reduced use of cement per ton of concrete poured. Neither the amount of concrete to be used in 2010, nor the reduction in cement per ton of concrete is certain at this time.

10a. **City facilities: refrigerants (PFC and HFCs)** Refrigerants – gases- are used in building mechanical systems to cool buildings and have very high global warming potential. The 2000 figure for CO2 equivalent emissions is based on discussions with engineers in the largest city buildings, and on data for system leakage in the Public Safety and Municipal buildings and fire and police stations. Lacking comprehensive data for city operations, this estimate could

understate total emissions in this category. Given the lack of data and the fact that in 2010 the Municipal and Public Safety buildings will no longer exist, no estimate is presented for refrigerants for 2010.

11a. **Employee business air travel** In 2000, according to data provided by the Finance Department, employees traveled at least 4.5 million miles on City business on commercial air liners. A figure of 0.34 kiloGrams per passenger air mile was used to calculate the total emissions, based on several current reports. The 2010 estimate was reduced by 10% to reflect continuing improvements in airplane efficiency over the next decade.

12.a **City facility energy use – electricity** This figure was arrived at by first calculating the emissions of CO2 per mWh sold by City Light then multiplying that by the total amount of electricity used in city operations and utilities for the year. The City electricity use for 2000 was provided by City Light staff. (Note: emissions associated with electricity use in City facilities has been subtracted from the total City Light emissions so this figure does not double-count City Light emissions.) However, emissions in this category are understated for two reasons: one, City Light data on electricity use in City operations do not include street lamps, traffic signals and some City Light facilities; and, two, data were not available for electricity use by City facilities outside City Limits, e.g., pump stations located in Puget Sound Energy service territory. The projected increase in 2010 in this category is due to the planned Cedar River water treatment plant which will be served by Puget Sound Energy; emissions were calculated assuming the new electric load is 5.5 mW which is met by an efficient combined cycle natural gas combustion turbine.

13a. **City facility energy use – steam heat** Steam heat (produced by natural gas) is purchased to heat several downtown City office buildings. Emissions were calculated using billing data from Seattle Steam. Projected emissions for 2010 were reduced to reflect the fact that in 2010 only the Arctic Building will be using steam heat.

14a. **Cedar River Watershed Forestry** This 95,000 acre property sequesters carbon in large amounts in 85,000 acres of forests. Recent research on carbon storage in Northwest forests and on carbon release due to commercial harvesting provides models for estimating these effects at the watershed. Commercial harvests ended in the mid-1990's and a ban on commercial harvests was legislated in 2000. Ecological thinning to encourage the growth of old-growth forest beginning in 2003 will account for very small amounts of carbon release, and the sequestration of carbon will become the dominant force by 2010. See "Carbon Dioxide Emissions at The Cedar River Watershed : The Effect of The Commercial Harvest Ban and New Forest Restoration Practices", OSE, 2002 for details.

Emissions Avoided

15a. **SPU recycling -** The majority of avoided emissions due to solid waste recycling occurs as a result of recycled material displacing the need to manufacture new product, thereby avoiding the use of fossil fuel energy used in manufacturing. Other emissions are avoided because less solid waste is transported and landfilled. Seattle Public Utilities used the US EPA waste reduction model, WARM, to generate the data, assuming the approximate 300,000 tons of material that was recycled in Seattle in 2000. The recycling goal for year 2010 has increased to 60%, so the benefits of recycling are considerably larger than those estimated for year 2000.

16a. **Electricity conservation –** The calculations are based upon Seattle City Light's conservation program savings of 224,800 MWh in 1990 and 708,500MWh in 2000. These energy savings meant that City Light avoided purchasing a like amount of energy that would have been generated by an energy efficient combined-cycle natural gas turbine. It is difficult at this time to estimate the emissions reductions due to electricity conservation programs at City Light in 2010.

17a. **Conservation savings – natural gas** – Through the City's Municipal Conservation Program, several City facilities retrofitted their facilities to be more energy efficient thereby reducing energy use.

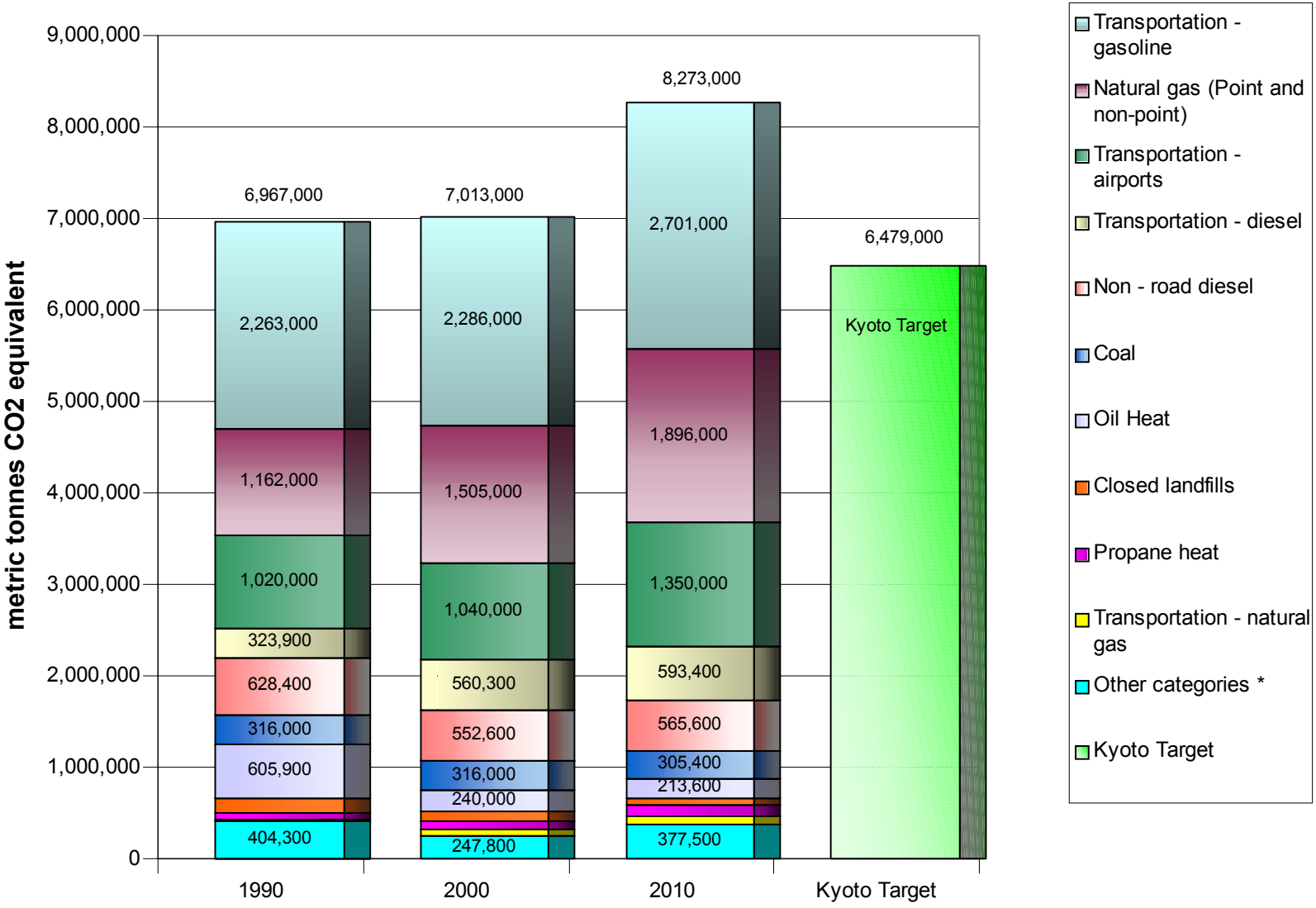
Table B: City of Seattle Greenhouse Gas Emissions Inventory - Citywide

(All emissions are displayed in metric tonnes and have been converted to CO2 equivalents; data is primarily courtesy of the Puget Sound Clean Air Agency.)

1b. Source	1990		2000		2010	
2b. Transportation – gasoline	2,263,000	32.5%	2,286,000	32.6%	2,701,000	32.6%
3b. Natural gas (Point and non-point)	1,162,000	16.7%	1,505,000	21.5%	1,896,000	22.9%
4b. Transportation - airports	1,020,000	14.6%	1,040,000	14.8%	1,350,000	16.3%
5b. Transportation - diesel	323,900	4.6%	560,300	8.0%	593,400	7.2%
6b. Non - road diesel	628,400	9.0%	552,600	7.9%	565,600	6.8%
7b. Coal	316,000	4.5%	316,000	4.5%	305,400	3.7%
8b. Oil Heat	605,900	8.7%	240,000	3.4%	213,600	2.6%
9b. Closed landfills	152,500	2.2%	99,800	1.4%	63,800	0.8%
10b. Propane heat	66,910	1.0%	105,000	1.5%	129,900	1.6%
11b. Transportation – natural gas	24,060	0.3%	60,520	0.9%	76,830	0.9%
12b. Other categories *	404,300	5.3%	247,800	3.5%	377,500	4.6%
Total	6,967,000	100.0%	7,013,000	100.0%	8,273,000	100.0%

* Other includes: Non road gasoline, distillate oil combustion, LPG combustion, fireplaces, point-source residual oil & point-source tires.

The Kyoto Protocol sets the US target for reducing greenhouse gas emissions at 7% below 1990 levels. For Seattle, that target would be 6,479,310 metric tonnes.



Graph 3: *GHG Emissions by Source for Seattle* (All emissions within City limits and a proportionate percentage of the SeaTac and King County airports. Data primarily courtesy of the Puget Sound Clean Air Agency.)

GHG Inventory: Citywide.
Explanations, notes, etc. for Table B.

Original source data is on file at the Office of Sustainability and Environment. Below is a summary of where the data was obtained, how it was compiled, etc.

1b. **Transportation - gasoline**. Each day, hundreds of thousands of cars, trucks, motorcycles, etc travel on Seattle's roads and highways which result in the largest single source of GHG emissions in Seattle (also included in this category is off-road use of gasoline such as for lawnmowers, leafblowers, etc.) The emissions were calculated by the Clean Air Agency by apportioning Seattle's population to total gasoline sales (provided by the Washington State Department of Transportation) for 1990, in King County, and for 1999, for the state. Although the data show only a nominal increase in gasoline emissions within the City, it's important to note that the Clean Air Agency's data do indicate a significant increase in the region: between 1990 and 2000, emissions went up by seven percent in the County (including Seattle) and in the four county region by 16 percent. The pounds of CO2 per thousand gallons of gasoline is based on EPA published standards (AP-42.)

2b. **Natural gas** (Point sources and non-point sources). Natural gas is used to heat homes and businesses (non-point) and for a number of manufacturing and industrial processes (point.) Point source gas data comes from the Clean Air Agency; small combustion sources data come from local companies' figures for annual natural gas sales to households, and census data about the number of households using natural gas in Seattle.

3b. **Transportation – SeaTac and King County Airport** The airline industry has, over the past 30 years, improved fuel economy per passenger mile by 61percent. Growth in air travel, however, has resulted in energy use by commercial aircraft nearly doubling in the same period[7] - which accounts for this category being the third largest source of GHG emissions. Emissions in this category were based on fuel sales data from the two airports (reported to the Clean Air Agency annually) and assigning a percentage of those sales to Seattle business and residents (Port of Seattle data indicate that 29% of passengers are from Seattle.) Emissions of CO2 from jet fuel and aviation gasoline were computed using IPCC methods.

4b. **Transportation/Construction – diesel** Diesel is used to fuel buses, trucks, trains, some passenger vehicles and a variety of heavy duty construction equipment, e.g., backhoes, road graders, etc. The data was supplied by the Clean Air Agency using the same calculations as described in note 1.

5b. **Coal from point sources.** Coal is still used by a few Seattle industries. The data was supplied by the Clean Air Agency. Coal combustion produces primarily CO2. The CO2 emissions were calculated using EPA standards (AP-42.)

6b. **Oil heat**. Homes are the largest users of oil heat. The ratio of oil heated homes in Seattle to oil heated homes statewide was applied to statewide oil sales as the basis for total oil use. The emissions factor for this source of CO2 comes from EPA standards (AP-42). Data was supplied by the Clean Air Agency.

7b. **Diesel – off-road**. This category includes one large source - shipping activity within Puget Sound --and three smaller sources: trains, ferries and construction equipment. (IPCC standards exclude international shipping in calculating GHG emissions.) *The USGH-98*

[7] Rocky Mountain Institute, Colorado.

standard was used to calculate CO2 emissions. The shipping data used the distance traveled within the sound, and an average consumption rate of 140 gallons per hour.

8b. **Closed landfills** This data consists of estimated emissions from several closed landfills within City limits – Interbay, Judkins Park, South Park, West Seattle and Montlake (those that have been closed for more than 30 years were not inventoried because they are generally not emitting any longer, that is, the decomposition process is complete.) Methane, which is 21 times more potent than CO2, is the gas at issue for this source. CO2 emissions from landfills are not counted because they come largely from biomass and reflect recycled carbon activity. The methane emissions data were reported by the Seattle Public Utilities Department, and by the Clean Air Agency. Emissions estimates are based upon estimated land-filled volume, or upon site-specific data emissions. Because complete emissions data were not available for Montlake and West Seattle, landfills that were privately owned, emissions in this category are somewhat understated.

9b. **Propane heat**. Statewide data on propane sales were scaled to Seattle using the ratio of Seattle households using propane to statewide households. The emissions factor for this source of CO2 comes from the EPA's AP-42 standards.

10b. **Transportation – natural gas** There is a growing number of compressed natural gas powered vehicles in use, primarily because it is a cleaner burning fuel. Data was supplied by the Clean Air Agency.

11b. **Other -** Non-road gasoline, distillate oil combustion, LPG combustion, fireplaces, point-source residential and point source tires.